PLANKTOS

August 15, 2007

To: ETAAC Members
From: Bill Coleman, COO, Planktos Inc.
Re: Additional Commentary regarding Planktos 'Game Changing Idea'

I would like to follow up regarding yesterday's review of greenhouse gas reduction 'Game Changing Ideas' in Sacramento. Undoubtedly members of the Committee have heard about Planktos' technology for ocean biomass carbon capture & sequestration. And it is likely that questions were in members' minds as public comment came to a close yesterday, even though none were asked during my brief appearance.

Planktos wishes to propose that its ocean biomass CCS technology qualifies for Committee consideration according to the six criteria by which ideas were solicited by the Committee, and that are examined below.

1) Efficiency: maximize emissions reductions

With properly balanced nutrients at hand, ocean phytoplankton are extremely efficient at converting sunlight to biomass during photosynthesis. Recent research (1997) has shown that the nutrient iron, delivered at parts per trillion concentrations (as happens naturally when wind-born dust is deposited in the open ocean) leads to fixation of about atmospheric CO2 at a ratio of 1:100,000. This means that 1 unit of iron dust delivered to the pelagic ocean removes 100,000 units of CO2 during photosynthesis. As a matter of normal biophysical process, a minimum of 20% of this fixed biomass will be exported as waste, dead or decaying material.

Thus, delivery of 100 tons of iron dust to a forest-sized patch of the pelagic ocean will lead to export of about 4 million tons of plankton biomass to long term storage (centuries to millennia) in the deep ocean. This will occur during a period of 120-180 *days*, the normal life cycle of an ocean plankton community.

2) Leverage: maximize private capital investment

The essence of the environmental marketplace, and market-based incentives for individuals or investment companies, is that private capital be used to support environmental or other goals in a socially responsible manner. Planktos has capitalized its operations with funds raised exclusively from private investors and/or investment institutions. This capital has been dedicated to restoring ecosystem services on land and in the open ocean. The capture and sequestration of atmospheric carbon remediates excessive levels of atmospheric CO2, now at about 400 ppm, or nearly 175% of background. The removal of CO2 from the air, in addition to emission reductions (pollution prevention), represents a combination of the two most fundamental methods for dealing with environmental degradation leading to global warming, climate change and related ocean decline.

Planktos' efforts to restore ocean ecosystem productivity, drawing exclusively on private sector resources and market mechanisms, represents optimal leverage benefiting the public interest.

3) Feasibility: difficulty of implementation

The technology for delivering missing nutrients (micro-scale iron) to the pelagic ocean is simple and straightforward, as are the formulations for optimizing iron uptake during photosynthesis. It is no more complicated than returning missing nutrients to backyard gardens or fields.

Methods for measuring and monitoring the results of iron restoration, including the export of biomass carbon to the deep ocean, have been under development and testing for many years within the marine science community. Planktos will be implementing 30-40 measuring, monitoring and verification (MMV) methodologies as part of its independently approved protocol. Planktos methods have been drawn from the marine science community.

Past researchers have posed questions about information they were not able to gather, owing to limited funding and at-sea time tied to the 10 international research projects undertaken since 1993. The average at-sea time for these projects has been about 20 days, with 50 days being the longest ocean excursion. Researchers were not able to observe the typical 120-day plankton bloom cycle, so have posed questions that Planktos will help answer during its upcoming meso-scale demonstration projects. Many of these same researchers have been invited to participate.

Restoration of ocean productivity from these demonstrations will help overcome a 25% decline in wind-born iron deposition, as well as 15% decline in ocean primary productivity since the 1980s (NASA 2003, 2006). This makes ocean restoration not only feasible but essential.

4) Pollution: minimize criteria and toxic pollutants

Iron is a natural ingredient in the ocean and part of a balanced 'diet' for plankton. Hundreds of millions of tons of fine iron rich dust are delivered each year to the ocean by circulating winds. This wind-blown dust generates plankton blooms that are millions of square kilometers large, that feed half the living things on the planet, and that exchange CO2 for oxygen in the air without negative side effects of any kind. Nonetheless, this dust is declining in volume, especially in the Pacific region, largely due to land coverage changes in Asia.

Planktos will be rejuvenating plankton communities that will follow the same patterns and processes that have been at work for millions of years, and to which the oceans are well adapted. Plankton blooms support a vast array of krill, salps, grazer fish, predator fish, harvest fish, sea mammals and sea birds. Many of these life forms have been declining, due not only to over fishing and poor habitat management (drag nets), but also due to outright starvation.

By returning a missing nutrient (iron) to the ocean 'soil' (surface waters), then monitoring and measuring the resulting increase in productivity, Planktos will facilitate a partial return of failing ocean productivity. This will mimic the way a farmer or forester works to optimize nature's productivity by restoring degraded fields or hillsides.

Questions have been raised about methane, NO2 or DMS produced by induced plankton blooms. The production of small quantities of such gases is a normal outcome of ocean biochemistry, occurring with every plankton bloom natural or managed, the same way that agricultural fields naturally generate some outgassing as a normal byproduct of vegetation life cycles. Restoring some measure of lost plankton productivity in small ocean patches cannot reasonably be argued

to influence the atmospheric gas balance. In any case, Planktos will carefully monitor and measure all such gases and provide transparent data sets for third party review.

5) Innovation: maximize innovation as opposed to expanding current best practice

Ocean biomass CCS is entirely new and innovative. At small scales, it has already been proven to work. What remains is to demonstrate this technology at meso-scales, in appropriate locations of the pelagic ocean. Researchers themselves have called for this scale up.

By virtue of the quantities (millions of tons sequestered per project), pace (4-6 *months* for life cycle closure), cost (less than $5 per ton sequestered), and important co-benefits (restored O2-CO2 exchange, species richness, harvestable protein and ocean economies), this technology deserves to be included in the larger toolkit of GHG management solutions.

6) Transitionality: focus on how near-term approaches to reducing GHGs can transition into longer-term reductions in GHGs, considering not only the technical challenges, but the commercial viability of each step along the way.

The rapid decline of pelagic plankton productivity since 1980 represents a loss of about 5 gigatons of reduced CO2 uptake from the atmosphere. This means that if plankton communities were simply *restored to 1980-type levels*, over 70% of the entire global annual anthropogenic contribution could be mitigated.

This represents an enormously important prospect for helping California, the nation and the world address the twin, interrelated dilemmas of climate change and ocean decline.

A transition strategy for ocean biomass CCS might include the following steps:

- Complete pilot demonstrations, with independent oversight & reporting
- Publish formal industry performance standards (protocols)
- Initiate a managed licensing procedure for offset providers
- Oversee a scheduled ramp-up of commercial undertakings
- Ensure that MMV achieves real-to-transparent performance criteria
- Selectively audit licensed offset provider accounts

Planktos has appealed to the Committee on several occasions for opportunities to tell the above story in enough detail that members would feel knowledgeable about this technology and the promise it represents. In this memo, we continue to do so; we are of the opinion that our technology meets all the criteria the Committee itself has used to evaluate Game Changing Ideas.

As the Committee's deliberations come a close Planktos continues to hope that we may learn either the Committee's questions regarding this proposed idea, or the Committee's reasons why the idea has been rejected.

Thanks once again for your consideration.